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The Effect of Participatory Forest Management on the Livelihood and Poverty of Settlers in a Rehabilitation Program of Degraded Forest in Bangladesh

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The sal forest is the only plainland forest in Bangladesh, and is of national economic and environmental importance. High population and ever increasing poverty has stimulated exploitation of the forest alarmingly and brought it near extinction. In facing this situation, the Bangladesh Forest Department implemented a participatory management approach, involving the householders living in and around the forests, for forest maintenance and protection. This study examines the effectiveness of practicing participatory forestry on the settlers' livelihood in the encroached area of the sal forest. The settlers were given degraded and encroached forest land through the program. Two major social forestry models – namely agroforestry and woodlots – are included in the study. Participation in the resettlement increased household income, employment opportunities and financial and non-land assets. It was found that the participatory management regime could attain the sustainability of the forest and accelerate the standard of settlers' livelihood, hence the program is an efficient management option towards sustainability of the forest resources. These findings suggest that there is a role for extending the approach to rehabilitate other degraded and encroached forest lands in Bangladesh.

Keywords: Participatory forest management; livelihood, poverty impact ratio, rehabilitation of degraded forest

INTRODUCTION

Bangladesh is a floodplain delta in the north eastern part of south Asia, between 20^{o} 34' and 26^{o}38' north latitude and 88^{o}01' and 92^{o}41' east longitude. The country has suffered from various disastrous events in managing forest resources since its independence in 1971. Thirty years ago the forest cover was approximately 70%, but due to overexploitation it had fallen to 13.4% in 2002. The sal (*Shorea robusta*) forest – covering 120,255 ha spread over the central and northern region – is of considerable environmental and economic importance, but is among the most

degraded forests in the country. *Shorea robusta* accounted for 70-75% of this forest, other valuable tree species including *Albizzia procers, Artocarpus chaplasa* and *Gmelina arbora*.

High population pressure and associated land-hungry agriculture, scarcity of dwelling places and unplanned urbanisation has led to notable degradation, poor stocking and almost extinction of the forest. Ethnic minorities and the ever increasing number of landless peasants have played a major role in the process of deforestation (Ahamed 1993). More than 60% of the sal forest was relatively densely wooded 30 years ago (Chowdury 1994). To control forest resource depletion, the Bangladesh Forest Department (FD) undertook a program involving the encroachers and rural poor living in and around it, to protect the sal forest. It was found in the Betagi-Pamora Community Forestry Project that if genuine landless farmers are properly organised around fallow and denuded lands, through proper management the output of these marginal lands could be increased substantially (Ahmed and Azad 1987).

Following this experience, the Forest Department (FD) initiated the participatory social forestry program in the sal forest for its maintenance and protection. It was expected by the FD that participatory management would increase the total benefit from the degraded land along with uplifting the socio-economic status of the settlers. Agroforestry and woodlot technology were the main technical aspects of the program. Generally the settlers were provided with 1 ha of land for plantation, without further land for a house site because they lived in and around the forest. In some cases, including where settlers were selected from other than the forest dwellers, they were provided with an additional 0.20 ha as a dwelling site and for homestead farming. Beneficiaries of the programs were chosen on the basis of high household need and low socio-economic status.

There were differences in design of the 'Betagi-Pomora' program of southern Bangladesh (mentioned above) and the participatory program of the central region (Tangail and Dhaka Forest Division) investigated in this paper. The former was designed for hilly tropical evergreen (non-deciduous) forest, by culturally heterogeneous tribal groups. While positive income and employment generation impacts were achieved, the program subsequently failed due the lack of cultural uniformity among the settler groups.

In the participatory social forestry program examined in this paper, the idea of involving rural poor was amalgamated with the aim of economic reorganisation of resources towards sustainable forest management and enhancement of socio-economic livelihood of the settlers (Ahmed 2000). The poverty reduction aspect was accorded high priority. The settlers were more uniform culturally. A study conducted on various income groups living in the degraded sal forest showed that timber production of reforested species increased substantially through participatory management between the Forest Department and the settlers (Alam 1998), and substantially improved the socio-economic condition of the settlers (Quddus *et al.* 1992). But these studies lacked focus on the socio-economic factors, indicators of living standard and the poverty reduction aspect of the settlers. Hence, the current study has attempted to examine the change in socio-economic structure due to participation in the program. Aspects considered include asset creation, income generation, employment generation, education and financial asset creation, as well as the poverty reduction impact of participatory management.

NATURE OF THE SETTLEMENT PROGRAMS

The agroforestry (AF) and woodlot (WL) technologies followed under participatory forestry management are similar in terms of input support, tenure rights, and forest maintenance. The landless rural people who live in and around the forest had been involved in establishment, maintenance and protection of the plantations. They were granted usufruct rights under a bilateral agreement with the Forest Department. The tenure right was initially sanctioned for seven years based on the sal rotation period. However, it was extended at the end of year 7 up to 10 years because of delays in completing the formalities required of public institutions before establishing forest management initiatives. In particular, there were lengthy delays in communication between the Forest Department and higher authorities such as Ministries.

Agroforestry and woodlot programs differ with respect to plantation design and sharing arrangement. Agroforestry was carried out on denuded and encroached forest land where the soil structure is suitable for intercropping, whereas woodlots were established on severely degraded forest land. The settlers were allocated to a plantation model by the Forest Department based on their interest and settlement position in and around the forest. Subsequent to program establishment, the Tree Farming Fund (TFF) was set to finance future plantations for settlers on their own. The TFF has been collected as a common fund to reduce the reliance on external financial support.

Revenue from timber production is distributed between settlers and the FD. The sharing arrangement of benefits from agroforestry is settlers 45%, FD 45% and TFF 10%, while for woodlots the shares are settlers 40%, FD 50% and TFF 10%. For the first rotation the FD and Asian Development Bank (ADB) provided financial support for the program; the settlers were not required to meet any of the costs, and were paid wages for their labour in the establishment activities. Also, finance was provided for inputs and maintenance of the farming activities. The agroforestry program was financially supported for the initial two years and for woodlot program for the initial three years.

The species selection was similar in the two programs but with differences in tree planting density (in stems per hectare, sph). The density was higher in woodlots (2500 from 3000 sph) than for agroforestry (1100 to 1200 sph depending on alley design). The distance between the rows was 1.5 to 2m, and the distance within row in alley cropping was 15 to 18m. Forest species planted included *Eucalyptus camaldulensis*, *Acacia auriculiformis*, *Acacia mangium* and *Terminalia arjuna*.

RESEARCH METHOD

This study compares the circumstances of the settlers with those of the non-settlers (NS, 'without program' group), who had no forest plantation activities, and were engaged mostly in traditional farming activities including rice production, seasonal vegetables and horticultural crops, on encroached and denuded forest land. A survey was conducted in October 2002, in the Dhaka and Tangail Forest Divisions, located in the central region of Bangladesh. A proportional stratified random sampling was employed, with samples of sizes 118 for agroforestry (AF), 157 for woodlots (WL) and 100 for non-settlers (NS), the sampling fraction being 0.46 for each group. A

questionnaire was developed to collect the desired information by personal interview of settlers, with secondary information gathered from the FD office, Range office and NGOs (including Bangladesh Rural Advancement Committee, PROSHIKA and ASHA). The information was segregated into 'with' and 'without' situations, in relation to participation in the program.

Statistical descriptive analysis and nonparametric comparison tests were used to assess the impact of participation on settlers' livelihood, in terms of the differences between the two programs and between the 'with' and 'without' program situations. Statistical tests were applied for differences in socio-economic characteristics of the respondents, including age, occupation, literacy, and ownership of assets. The Kolmogorov-Smirnov one-sample test was applied to check the normality assumption of the distributions of sampled variables. The statistics showed a drastic departure from the normality assumption, which led to use of non-parametric comparison tests. The Kolmogorov-Smirnov Z nonparametric test (for two independent samples) has been used for determining inter-group (AF and WL or AF and NS or WL and NS) differences[1], and the Kruskull-Wallis (non-parametric ANOVA) test has been used to examining overall group (AF, WL and NS) differences. A further step in the research method is to derive the poverty impact ratio (PIR) for the settlers, so as to make inferences about the change in their poverty level relative to other households in the program district. This analysis is described in the next section.

POVERTY IMPACT ANALYSIS

A poverty impact ratio (PIR) is the proportion of net economic benefits accruing to the poor, compared to the total economic benefits of a project or program. The ratio compares an estimate of the poverty index of the participating groups with that of the local poor population to determine whether there is any impact on poverty (ADB 2001). A PIR greater than the prevailing local poverty line indicates that the program has a positive impact on poverty reduction. Applied to the participatory forestry program, the PIR indicates the portion of net economic benefit of the program that reaches the settlers considered to be poor. The benefit going to the poor is the income accruing to them by joining the program, assuming they had a similar poverty level to the local population prior to the program.

The poverty impact ratio (PIR) is defined as:

$$\text{PIR} = \frac{\sum_{i=1}^{n} B_1 P_{B_1} + B_2 P_{B_2} + B_3 P_{B_3} + \ldots\ldots\ldots\ldots + B_n P_{B_n}}{\sum_{i=1}^{n} B_1 + B_2 + B_3 + \ldots\ldots\ldots\ldots + B_n}$$

where i (= 1 to n) indicates the number of stakeholders, B_i is the net benefit in benefit category i, and P_{Bi} is the proportion of benefit in benefit category i that goes to the target group of poor.

[1] This test is described by Norsusis 1999, Coakes and Steed 2001 and Easton and McColl 2003.

A number of applications of the PIR methodology are to be found in the literature. A study by the Asian Development Bank of a water development project revealed a positive poverty reduction impact (ADB 1999). The analysis assumed that the net economic benefit to the poor from the public expenditure was 50%, and that 30% of labour wage had been received by the participants who provided their physical labour. Project output met the need of 20% of people of the locality who were below the poverty line. The PIR was assessed in relation to the population and it was estimated 0.26 which indicates a positive poverty reduction impact.

Extension research was conducted by ADB (2001) for three sub-projects of the *Viet Nam: Second Red River Basin Water Resource Sector Project*. The Yen Binh sub-project was found to have a PIR greater than unity (1.14) and that for the Ngia Lo sub-project 6.96. These two sub-projects targeted the 'ultra-pro-poor' and their benefits accruing to the poor were considerably greater than their income effect. In contrast, the Giha Thuan sub-project had a PIR of only 0.30.

The ADB (2002) conducted another study in Tajikistan on a road development project, for an area in which 60% of the users were classed as poor. The researcher also pointed that these poor people use buses as frequently as better-off passengers. From the cash flow analysis, the poverty impact ratio was estimated at 0.44 which is lower than the local poverty index, indicating that the benefit distribution of the road development project did not favour the poor. A further poverty reduction impact analysis conducted by the ADB (2002) for the *Renewable Energy Development Sector Project to the Republic of Indonesia* revealed a positive distributional impact on the poor.

In this study, the settlers are considered the target group of poor, and it is assumed that they receive a specific portion of the benefit generated to each benefit category from the program. The local poverty line (upper poverty line) is taken as that of the Dhaka Division, which has been estimated by the Department of Statistics and Information as 0.52 (BBS 2000).[2]

In this study a comparison has been made to determine the poverty reduction impact of the participatory social forestry program. The net economic benefits to the major stakeholders or entities – namely settlers (considered poor), government (FD) and consumers (the people living in and around the forest including settlers) are first estimated. This involves financial, economic and distribution analysis (gains and losses). The proportion of government expenditure to the settler was assumed to be 50%. The settlers were paid wages for their labour employment in the program at the initial stage, the full (100%) benefit of which is assumed to accrue to them. In addition, consumers (settlers and locals), are assumed to receive 100% of the timber, crops and other by-products produced by the settlers, and these products are considered to meet fully the demand of the area. Because various assumptions are required in estimating the contributions that accrue to the poor, a sensitivity analysis has been conducted.

[2] This estimation has been obtained using the 'Cost of Basic Need Method' (BBS 2000), which identifies the income level needed by the people to afford the basic necessities to survive.

RESULTS AND DISCUSSION

Family Size

The average family size of settler households in the study area was just under five members (Table 1). The mean family size does not vary significantly among the three groups of respondents (Table 11)[3]. The sample mean family sizes of the three groups were lower than the national and regional averages[4]. Large families are considered to create a financial burden in Bangladesh. The project area is near the capital city where many NGOs are working for family planning, and after joining the program the settlers were motivated by NGO social workers that helped them to keep their family sizes small.

Table 1. Average family size of respondent households (n=375)

Group	Total number of households surveyed	Total number of family members	Average family size
WL	157	814	5.18
AF	118	615	5.21
NS	100	409	4.09
Total	375	1,838	4.90

Age Distribution of the Respondents

The respondents were classified into five age classes (Table 2). The mean age of the respondents of WL, AF and NS are 48, 47 and 38 years respectively, with an overall mean of 45 years. There is a greater proportion of older respondents from the 'with participation' group, particularly the WL group. There is a significant difference between the mean age of the settler and the non-settler group at the 1% level (Table 12). This is due to temporary settlement in the NS group of middle-age headed households who are mostly from the river eroded area and are seeking permanent employment in an urban area. They are sufficiently young to migrate from one area to another, in contrast with program participants who moved to the program area some years ago.

Education Level of the Settlers

The settlers were classified as illiterate (no reading or writing ability), can write only (able to write the alphabet but with little reading ability), and literate (able to read and write a letter), with the literate group further classified into five groups according to number of years of education. As reported in Table 3, more than half of the respondents (55.5%) are illiterate, while 18.9% 'can write only'. The illiteracy rate is highest for the non-settler group (65%), followed by the WL then AF group. More than 40% of settlers under the literate category have only first to fifth grade (Primary level) education. The HSC (Higher Secondary School Certificate) and

[3] Tables 9-11 report statistical tests to compare means between the WL, AF and NS groups.

[4] According to the 1991 Bangladesh Population census, the national average family size in Bangladesh is 5.6, while the averages in the Dhaka and Tangail Divisions are 6.7 and 6.3 respectively (BBS 2000).

graduate level literacy is very low among the respondents (3.73% and 0.27% respectively). The education levels of the respondents do not differ significantly across the three groups (Table 11). The literacy rate of the respondents is one-third that of the national average reported by Bartleby (2004) as 43.1%. Low literacy is considered a major cause of poverty throughout Bangladesh.

Table 2. Age distribution of respondents (n=375)

Group	Age group[a]					Mean age	Total
	15-24	25-34	35-44	45-59	60+		
WL	0 -	12 (7.6)	35 (22.4)	79 (50.3)	31 (19.8)	48.5	157
AF	0 -	12 (10.2)	33 (28.0)	45 (38.1)	28 (23.7)	47.5	118
NS	8 (8.00)	33 (33.0)	30 (30.0)	20 (20.0)	9 (9.0)	37.7	100

a. Figures in parentheses are percentages.

Table 3. Education level of the settlers

Group	Education level[a]							
	Illiterate	Can write only	Literate					
			I-V	VI-X	SSC	HSC	Graduate	Total
WL	88 (56)	30 (19)	13 (8)	11 (7)	5 (3)	9 (6)	1 (1)	39 (25)
AF	55 (47)	30 (25)	17 (14)	9 (8)	4 (3)	3 (3)	- -	33 (28)
NS	65 (65)	11 (11)	11 (11)	10 (10)	1 (1)	2 (2)	- -	24 (24)
Total	208 (55.5)	71 (18.9)	41 (10.9)	30 (8.0)	10 (2.7)	14 (3.7)	1 (0.3)	96 (25.6)

a. Figures in parentheses are percentages.

Main Occupations of the Settlers

In terms of occupation (Table 4), just under 60% of the settlers were engaged as agricultural labourers, paid wages on a daily basis, followed by agricultural professions (15.47%) including poultry farming, crop production and fishing. Among other categories, only 9% of the settlers had service as their main occupation, followed by small trading (5%) and non-agriculture, including day-labour in the industrial area (4%). Among these three groups the NS are less engaged in agricultural labouring activities.

Table 4. Main occupations of settlers

Class of occupation	WL		AF		NS		Total	
	No	%	No	%	No	%	No	%
Agricultural labourers	95	60.1	71	60.2	55	55.0	221	58.9
Agricultural professions	28	17.8	13	11.0	17	17.0	58	15.5
Non-agriculture	4	2.6	5	4.2	5	5.0	14	3.7
Service	10	6.4	10	8.5	11	11.0	31	8.3
Small trading	14	8.9	-	0.0	4	4.0	18	4.8
Others	6	4.0	19	16.0	8	8.0	33	9.0
Total	157		118		100		375	

Living Standard of the Settlers

A number of indicators were chosen to assess the living standard of the settlers (Table 5). Relatively few had electricity connection, the power supply system in the forest area being inadequate. Most used a local lamp for lighting. Sixty-nine percent owned tube-wells as the source of their drinking water (with the proportion highest in the AF group), 17% used a government tube-well and the remainder used tube-wells owned by others. According to 91% of the settlers, the quality of drinking water was high, and not badly affected by the acidity of the local soils, although some respondents suffered from scarcity of suitable drinking water.

In order to examine the hygienic environment of the study area, the type of latrine that the settlers use in their daily life was considered, ranked on the basis of safety as septic, pit latrine, hand made and open. Most of the settlers (45%) use pit latrine; a small number (12%) had installed the more expensive and hygienic septic latrine.

Type of medical care is also an indictor of health awareness of the settlers. Only 64% visited a registered doctor (the most expensive form of treatment), a slightly higher proportion attending a homeopath. Also, 35% sought treatment by an unqualified practitioner (or ‘quack’) and 18% went to a herbalist.

Practices concerning the deposit of financial assets provide an indication of savings and security attitudes. Most of the settlers (93.9%) retain their money at home. Only 14.7% deposit their money into a bank (the most secure option), while a few deposit money with the post office or neighbours. These findings reveal that settlers are not accustomed to the use of institutions for saving their monetary assets, or with social development in general.

Table 5. Living indicators of the settlers' standard of living[a]

Item	Indicator	WL	AF	NS	Total
Lighting facilities	Local lamp	115 (73)	85 (72)	58 (58)	258 (68.8)
	Electricity	42 (26)	36 (31)	19 (19)	52 (13.9)
Drinking water source	Own tube-well	104 (66)	90 (76)	66 (66)	260 (69.3)
	Public tube-well	10 (6)	6 (5)	1 (1)	17 (4.5)
	Other's tube- well	43 (27)	23 (19)	33 (33)	99 (26.4)
Quality of Drinking water	Good	144 (92)	104 (88)	95 (95)	343 (91.8)
	Not good	13 (8)	3 (3)	5 (5)	8 (2.1)
	Salty	0	11 (9)	-	11 (2.9)
Type of latrine	Septic	22 (14)	7 (6)	15 (15)	44 (11.7)
	Pit latrine	67 (43)	70 (59)	33 (33)	170 (45.3)
	Open	14 (9)	9 (8)	12 (12)	35 (9.3)
	Hand made	53 (34)	29 (25)	-	82 (21.9)
Medicare	Quack	43 (27)	45 (38)	42 (42)	130 (34.7)
	Homeopath	101 (64)	73 (62)	75 (75)	249 (66.4)
	Registered doctor	103 (66)	74 (63)	61 (61)	238 (63.5)
	Herbal	15 (10)	3 (3)	-	18 (4.8)
Place of depositing money	Self	143 (91)	110 (93)	99 (99)	352 (93.9)
	Neighbours	1 (1)	-	-	1 (0.37)
	Post office	1 (1	1 (1)	-	2 (0.5)
	Bank	31 (20)	20 (17)	4 (4)	55 (14.7)

a. Figures in parentheses are percentages.

Yearly Family Expenditure

Yearly household expenditure was grouped according to food, beverages, tobacco, fuel, clothing, medical care, education and other expenses (Table 6). The highest proportion of the income is spent on food, as a basic necessity of daily life. All three groups spent the second highest proportion of their income on clothing. The average food expenditure is slightly higher in the WL group that the other groups. The yearly total household expenditure (sum of mean expenditure for each item) is Taka (Tk[5]) 85,534.

Table 6. Mean yearly household expenditure of the settlers by expenditure item

Expenditure item	WL		AF		NS		Totals by means
	No	Mean (Tk)	No.	Mean (Tk)	No.	Mean (Tk)	
Food	157	19,991	118	17,814	100	14,578	52,383
Beverage	99	1,115	62	739	46	668	2,522
Tobacco	132	800	92	626	78	672	2,098
Fuel	157	1,579	118	1,749	100	1,177	4,505
Clothing	157	2,617	118	1,974	100	1,637	6,227
Medical care	157	850	118	659	100	719	2,228
Education	121	1,785	83	1,290	59	1,681	4,757
Construction	110	815	90	822	70	593	2,230
Travel	156	1,186	118	786	100	795	2,768
Social	154	2,270	118	1,931	100	1,613	5,814
Total	154	33,008	118	28,391	100	24,134	85,533

Using the Kruskull-Wallis test it was found (at the 1% level) that expenditure on food, fuel and clothing differs significantly between settler and non-settler groups (Table 7). Mean expenditure on beverage and social activities differs between groups at the 5% significance level.

Table 7. Mean difference in household expenditure between settler and non-settler groups

Expenditure item	Chi-square statistic	p-value
Food	29.50	0.000**
Beverage	5.11	0.024*
Tobacco	0.00	0.958
Fuel	12.47	0.000**
Clothing and footwear	17.53	0.000**
Medicare	1.33	0.249
Education	2.23	0.135
Construction	0.85	0.357
Travel	1.75	0.186
Social activities	8.24	0.004*
Loan repayment	0.00	0.948

* Significant at 5% level; ** significant at 1% level.

[5] US$1.00 = Tk8.78 (Xe 2004).

Using the Kruskull-Wallis test, it was found that expenditure for food and clothing differs significantly between the three groups (WL, AF and NS) at the 1% level. Mean expenditures on beverages, fuel, construction and social activities vary between groups at the 5% significance level. Table 8 shows the result of the Kruskull-Wallis test for determining significant difference among the three groups of respondent.

Table 8. Mean difference in household expenditures among WL, AF and NS

Expenditure item	Chi-square statistic	p-value
Food	36.98	0.000**
Beverage	8.16	0.017*
Tobacco	3.16	0.206
Fuel	14.64	0.001*
Clothing and footwear	21.06	0.000**
Medicare	4.79	0.091
Education	2.37	0.306
Construction	8.67	0.013*
Travel	4.34	0.114
Social activities	9.28	0.010*
Loan repayment	5.57	0.062

* Significant at 5 percent level, ** significant at 1 percent level

Financial Asset Structure of the Settlers

Financial assets of the settlers – comprising amounts deposited in the bank plus amount lent to others (with interest or without) in a given year – have been grouped into six categories (Table 9). Almost all settlers had monetary deposits of more than Tk5000. Few had deposits of more than Tk10,000, the greatest proportion being in the AF group. The fraction of non-settlers with very low savings is greatest in the NS group. There is no significant difference among the three groups of respondents in terms of total amount of savings (Table 11).

Table 9. Financial assets of the respondents (Tk)

Group	Item	Level of financial assets (Tk)					
		<5000	5001-10000	10001-15000	15001-20000	20001-25000	25001+
WL	No.	57	32	2	2	1	1
	Mean	1,559	7,019	11,852	17,105	20,560	36,420
	%	60.0	33.7	2.0	2.0	1.1	1.1
AF	No.	86	32	10	3	4	1
	Mean	1,650	6,928	12,375	18,538	22,208	48,400
	%	63.2	23.5	7.4	2.2	2.9	0.7
NS	No.	61	14	4	-	1	1
	Mean	1,865	6,858	11,677	-	21,315	40,110
	%	75.3	17.3	4.9	-	1.2	1.2
Total	No.	204	78	16	5	6	3
	Mean	1,691	6,935	11,968	17,821	21,361	41,643

Difference in the Socio-economic Variables among WL, AF and NS

Statistical tests had been carried out to identify differences in socio-economic variables for the three groups. The Kruskul-Wallis test had been used to examine the inter-group mean difference among AF, WL and NS (Table 10). Age, family size and yearly income differ significantly between groups at the 1% level.

Table 10. Test statistics for comparison between groups (WL, AF and NS) for socio-economic variables

Variable	Chi-square statistic	P-value
Age (years)	52.278	0.000**
Education (years)	4.634	0.099
Family size (number)	26.886	0.000**
Financial asset (Tk)	2.685	0.261
Physical asset (Tk)	3.427	0.180
Yearly expenditure (Tk)	15.897	0.000**

* Significant at 5% level; ** significant at 1% level.

Two further tests were carried out to detect differences in characteristics of settlers and non-settlers. The Kolmogorov-Smirnov Z (two-independent nonparametric sample test) was used for testing mean differences. The variables considered are age, education, family size, financial assets, physical assets, yearly expenditure, area of garden, income of garden and income of timber. Between agroforestry and woodlot settlers the mean area of garden, income of garden and income of timber are significantly asymptotically different between groups at the 1% level (Table 11). Between settlers and non-settlers, age of respondent, family size and yearly expenditure are significantly asymptotically different at the 1% level (Table 12). This indicates that differences between the AF and WL settlement models may affect the settlers' livelihoods.

Table 11. Kolmogorov-Smirnov Z statistics for the mean difference of socio-economic variables between AF and WL

Variable	Kolmogorov-Smirnov Z	Asymptotic significance (2-tailed test)
Age (years)	0.760	0.610
Education (years)	0.775	0.586
Family size (number)	0.693	0.722
Financial asset (Tk)	0.850	0.466
Physical asset (Tk)	0.847	0.470
Yearly expenditure (Tk)	0.672	0.758
Area of garden (ha)	4.741	0.000**
Income of garden (Tk)	1.708	0.006*
Income of timber/ha (Tk)	1.708	0.006*

* Significant at 5% level; ** significant at 1% level.

Table 12. Kolmogorov-Smirnov Z statistics for the mean difference of socio-economic variables between settler and non-settler

Variable	Kolmogorov-Smirnov Z	Asymptotic significance (2-tailed test)
Age (years)	3.246	0.000*
Education (years)	1.113	0.168
Family size (number)	2.024	0.001*
Financial asset (Tk)	0.712	0.691
Physical asset (Tk)	1.152	0.141
Yearly expenditure (Tk)	1.946	0.001*

Poverty Reduction Impact of AF and WL

It was anticipated that settlement of rural poor in forest areas would lead to poverty reduction. Table 13 shows the result of poverty impact analysis of participatory management. The proportion of poor was determined based on the public policy and the Forest Department's policy. The distributions of benefit between government (FD), settlers and consumers involved in the project area are reported in Table 13. Due to the participatory program, these three parties benefited by receiving income, employment and consumption goods from the forest.

The PIR of the participatory management (WL and AF together) is estimated as 0.95 (Table 13). This figure is greater than the prevailing poverty line (0.52) of the locality, indicating that there has been a poverty reduction for settlers in the participatory program.

Table 13. Poverty reduction impact of the participatory forestry management

Item	Government	Settler	Consumers	Total
Benefit (Tk1000)[6]	46.38	13.94	510.72	571.04
Proportion of benefit[7]	0.5	1.0	1.0	2.5
Benefit to poor (Tk1000)[6]	23.19	13.94	510.72	547.85
Poverty impact ratio			0.9594	

The proportion of economic benefit to the poor is uncertain, and could affect national policy and other factors. Sensitivity analysis (Table 14 and Appendix A) indicates that the poverty reduction impact of settlement is relatively robust to variations in benefit shares between beneficiary groups. However, when the relative share to the consumer group is reduced to 50%, the PIR falls to the prevailing poverty line of the locality.

[6] Estimated on a per hectare basis.
[7] Expressed as proportions rather than percentages.

Table 14. Sensitivity analysis of Poverty Impact Ratio to different proportions of benefit[8]

Proportion of benefit			Poverty Impact Ratio (PIR)
Government	Settler	Consumer	
0.50	0.70	1.00	0.9521
0.75	0.50	0.50	0.5203
0.75	0.50	0.75	0.7439
0.75	1.00	0.75	0.7561

CONCLUDING COMMENTS

Participatory management has had a positive impact on settlers' livelihoods as well as on sustainability of the forest resource. According to statistical tests, agroforestry has a greater positive impact on the livelihood of the settlers than woodlots. Living standards have been found to be higher for settlers than non-settlers. The Poverty Impact Ratio is greater for settlers than the poverty line of local residents in the region, indicating that the participation of rural poor in rehabilitating the forest has positive poverty reduction impact on society as well as on individual settler. This suggests that there would be social benefits from replicating the participatory social forestry program in other degraded forest areas. However, it would be desirable to make some modifications to the program, to make it more sustainable. Modifications might include loan facilities for the female members of the settlers' families so that they could be involved in income generation, infrastructure development for the inhabitants, provision of other technology such as beekeeping and bamboo farming, and greater security of tenure.

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[8] Derivation of PIR values is reported in Appendix A.

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Appendix A

Poverty Impact Ratios for Various Benefit Proportions to Government, Settlers and Consumers

Case I

Item	Government	Settler	Consumers	Total
Benefit (Tk1000)[9]	46.38	13.94	510.72	571.04
Proportion of benefit[10]	0.5	0.7	1.0	2.2
Benefit to poor (Tk1000)[9]	23.19	9.758	510.72	543.668
Poverty impact ratio			0.9521	

Case II

Item	Government	Settler	Consumers	Total
Benefit (Tk1000)[9]	46.38	13.94	510.72	571.04
Proportion of benefit[11]	0.75	0.5	0.5	2.5
Benefit to poor (Tk1000)[9]	34.785	6.97	255.36	297.115
Poverty impact ratio			0.5203	

Case III

Item	Government	Settler	Consumers	Total
Benefit (Tk1000)[9]	46.38	13.94	510.72	571.04
Proportion of benefit[11]	0.75	0.5	0.75	2.5
Benefit to poor (Tk1000)[9]	34.785	6.97	383.04	424.795
Poverty impact ratio			0.7439	

Case IV

Item	Government	Settler	Consumers	Total
Benefit (Tk1000)[9]	46.38	13.94	510.72	571.04
Proportion of benefit[11]	0.75	1.0	0.75	2.5
Benefit to poor (Tk1000)[9]	34.785	13.94	383.04	431.765
Poverty impact ratio			0.7561	

[9] Estimated on a per hectare basis.
[10] Expressed as proportions rather than percentages.